Northern Sandplain Kwongan: regeneration following fire, juvenile period and flowering phenology

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Abstract

Fire is an integral factor in the ecology and management of the shrub lands of the Northern Sandplains in Western Australia. Documentation of fire effects on 192 species from a range of edaphic conditions revealed that 73% were capable of resprouting after fire. Both resprouting and reseeding species resumed flowering quickly following fire with 79% of the species flowering within two years. Particular species requiring longer juvenile periods, however, could have important management consideration due to their status as pollen species for apiculture or their conservation status. Flowering peaked in September in this study region and there were no major differences in phenology of more recently burned sites compared with mature shrublands. The interaction of the use of fire to protect human developments and the desired maintenance of areas of unburnt shrubland for honeybee pastures and biological species preservation is discussed.

Introduction

Fire is an integral factor in the shrub-dominated ecosystems throughout the world (Specht 1979). The plants of these communities possess numerous adaptations which enable them to regenerate after fire, such as sprouting from buds located in underground organs and fire-stimulated seed germination. Studies on the effect of fires on shrub-dominated heaths in Australia have shown that most of the species regenerate after fire by sprouting (Specht *et al.* 1958, Siddiqi *et al.* 1976, Russell and Parson 1978, Bell *et al.* 1984, Bell 1985). In these communities the species which lack the ability to resprout, i.e. obligate seeders, regenerate either by fire-stimulated germination of seed stored in the soil or by dispersal of seed held in woody fruits. The effect of fire on soil-stored seed is well documented (Stone and Juhren 1951, Went *et al* 1952, Cushwa *et al.* 1952, Christensen and Muller 1975). The depth and intensity of heat through the soil profile during a fire is an important factor in determining post-fire regeneration (Shea *et al.* 1979). A very hot fire may kill underground organs (Hopkins 1979) and soil-stored seed, whereas a fire of low intensity may not stimulate some seed to germinate (McArthur and Cheney 1966).

Some Australian plant species, eg. *Xanthorrhoea* spp. and a few species of the Orchidaceae actually depend on fire to stimulate flowering (Gill 1975). Most plants, however, require a certain time after a fire before reproduction begins. This period, termed the "juvenile period", is least important for plants regenerating after fire by sprouting but is an important characteristic of plants regenerating from seed. Time since last fire may also have an impact on the annual period of flowering.

The Northern Sandplain shrublands have probably been subjected to periodic fires for at least the past 5 000 years (Churchill 1968). Under conditions prior to the settlement of the region by European man, the region probably received fires on a cycle of some 25 years (Bell 1985). Today fire frequencies are higher due to man-caused fires (Bell *et al.* 1984) and a controlled-burning regime must be imposed on certain regions under management (Bell and Loneragan 1985).

Some of the Northern Sandplain shrublands have been reserved in National Parks and Nature Reserves, but extensive areas have been cleared for agricultural, pastoral and mining land uses. Uncleared land serves a number of economic purposes including the tourist industry and the cut-flower and native seed collection trades. The Northern Sandplain native shrublands also serve as winter season "honeybee pastures" for commercial apiarists. The beekeeping industry uses the native shrublands and especially the pollen produced by winter-flowering species to maintain hives and to build up worker bee numbers for the honey production seasons in the south-western forest regions later in the year.

Fire management in the Northern Sandplain must provide sufficient areas of prolific shrublands to serve the needs of commercial apiculture while protecting life and property in the adjacent wheat and pasture developments. Information on the impact of fires on the shrublands is of primary importance to the apiculture industry and aspects of species conservation. Conservation of community types and the flora and fauna of regions of this rich (Lamont *et al.* 1984) and highly endemic (Rye 1982) shrubland must also consider the impact of fire (Bell *et al.* 1984). The following study was designed to provide information on the influence of fire on the mode of regeneration, the length of the juvenile period and the flowering phenology for species of these Northern Sandplain shrublands.

Methods

Twenty-six permanently marked 20 m x 10 m plots were established in Northern Sandplain shrublands near Badgingarra, Western Australia (30°16'S, 115°26'E). The sites were representative of a range of topographic sites and ages-since-last-fire. Each site was initially categorized as lateritic upland or deep sand slope as these edaphic conditions have proved to produce the major floristic differences in the vegetation of this region (Bell and Loneragan 1985). The ages of more recently burned sites were determined by records of the Western Australian Bush Fire Board. Sites burned before 11 years ago could not be exactly documented and were grouped as >11 years. Each site was visited monthly from March 1981 till December 1981 and a list of species in flower was compiled.

Post-fire regeneration strategies were determined from recently burnt sites. Obligate seed regenerating species could be recognized because they initially have only a single erect stem. These seedlings were clearly differentiated from resprouting species which tend to be multi-stemmed. Geophytes were classed as sprouters since they regenerate after fire by producing new shoots from underground storage organs.

Results and Discussion

Resprouting after fire

During the study 238 species were identified (Table 1, Appendix 1). The range of sites allowed particular species to be assigned to edaphic preference categories. Among the 192 species identified in this way, approximately equal numbers were subjectively assigned to the generalist (or edaphically indifferent), lateritic or sand specialist categories. The vegetation patterns in the Northern Sandplain shrublands have previously been shown to correspond strongly to the major differences in soil conditions, but fire was also shown to influence the floristic composition of stands in these shrublands (Bell and Loneragan 1985).

Categorizing species of the Northern Sandplain study sites into mode of regeneration after fire revealed that 73% of the 192 species recorded in this way were capable of resprouting after fire. This division of sprouters and obligate seeders is similar to shrubland sites in eastern Australia where the reported percentages of sprouters includes 70% in South Australia (Specht *et al.* 1958), 73% in Victoria (Russell and Parsons 1978) and 80% for the coastal heaths of New South Wales (Siddiqi *et al.* 1976). The sclerophyllous shrub-dominated understorey of the jarrah forest of the Darling Range also contains a similar proportion of resprouting species (Christensen and Kimber 1975, Bell and Koch 1980). In a more limited study of predominantly deep sand sites in the Northern Sandplain, resprouter species represented 66% of the total (Bell *et al.* 1984).

Table 1

Summary statistics for the fire response survey in the Northern Sandplain shrublands near Badgingarra, Western Australia.

Total Species Identified in studies	Total 238			
Species Categorized for Edaphic Preference	Total 197	Generalists 72	Sand 61	Laterite 64
Species Categorized for Regeneration Strategy	Total 192	Sprouter 126	Seeder 51	Both 15
Species Categorized for Juvenile Period	Total 108	<2 yrs 87	>2<4 yrs 16	>4 yrs 5
Species in Phenology Study	Total 149			

The "sprouting" habit is considered an adaptation to recurring fire (Biswell 1974). Conversely, a long fire-free period was probably important in evolving the obligate seeding strategy (Keeley and Zedler 1978). However, it is uncertain whether the characters such as sprouting, woody fruits and hard seeds are adaptations specifically to fire or adaptations to other environmental factors, such as a low nutrient regime (Specht 1979), drought (Hnatiuk and Hopkins 1980) or insect damage (Morrow 1977). Whatever their origin, these adaptations ensure survival in the fire-prone regions of the Northern Sandplain.

Many of the tall shrubs of the Badgingarra shrublands are obligate seeders, e.g. *Hakea obliqua, Adenanthos cygnorum, Dryandra sessilis.* This relationship of size with regeneration mode was also identified in Kings Park, Western Australia (Baird 1977). The significance of this relationship, however, is obscure. A number of the obligate seeders possessed the bradysporous habit (Specht 1979), i.e. seeds are retained in woody fruits or cones until a fire opens the fruit. Examples of species with this habit in Western Australian heathlands are *Hakea obliqua, Eremaea fimbriata* and *Beaufortia elegans.* Other obligate seeders such as *Acacia pulchella* and *Kennedia prostrata* possess "hard" seeds (Ewart 1908). These seeds remain viable and dormant for long periods in the soil until some event, usually fire, stimulates them to germinate. The effect of fire on these hard seeds is to crack the seedcoat making it permeable to moisture and oxygen (Beadle 1940; Floyd 1966, 1976). As hard seeds can remain viable in the soil for many years even after the parent plants have died, species richness and diversity often increases following managed fuel-reduction fires (Bell and Koch 1980).

Flowering phenology

Throughout the 26 shrubland sites the maximum flowering period occurred in spring with a peak of 74 species recorded on September 29th (Fig. 1, Apendix 1). Common winter flowering species were *Leucopogon conostephioides, Andersonia lehmanniana and Stylidium repens.* In late winter and early spring *Hibbertia crassifolia, H. hypericoides* and *Drosera heterophylla* were flowering abundantly in most sites. With the onset of spring many more species began their flowering period and no species dominated flowering throughout all sites. *Calothamnus sanguineus* was the only species which flowered throughout the sampling period.

The rapid increase in flowering species towards spring was associated with an increase in flowering for species of the families Myrtaceae and Proteaceae and a decrease in the Epacridaceae (Fig. 2). The winter maxima for members of the Epacridaceae are important as members of this family are reported to be favoured apicultural species (Smith 1969).

In comparing the flowering periods between sites varying in the time-since-last-fire, only two species, *Hypocalymma xanthopetalum* and *Hovea stricta* showed a different phenological pattern between the recently burnt and long unburnt sites. *Hypocalymma xanthopetalum* flowered in two year old sites as much as two months before it flowered in any of the older sites. *Hovea stricta* flowered in two- and five-year-old sites, also two months before it flowered in the greater than eleven-year-old sites. In general, however, stand-age had little relationship to the period of availability for honeybee use once the juvenile period was completed.

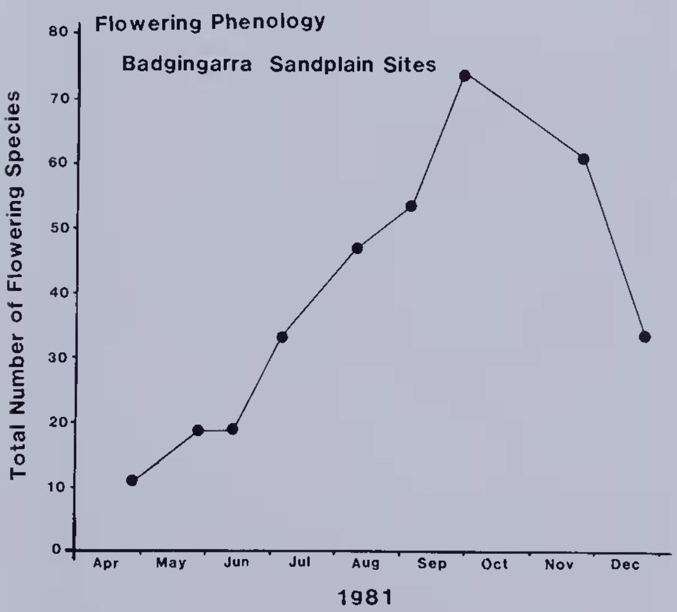

Figure 1.—Total number of species flowering in 26 heathland study sites in the Northern Sandplain during the period April through December 1981.

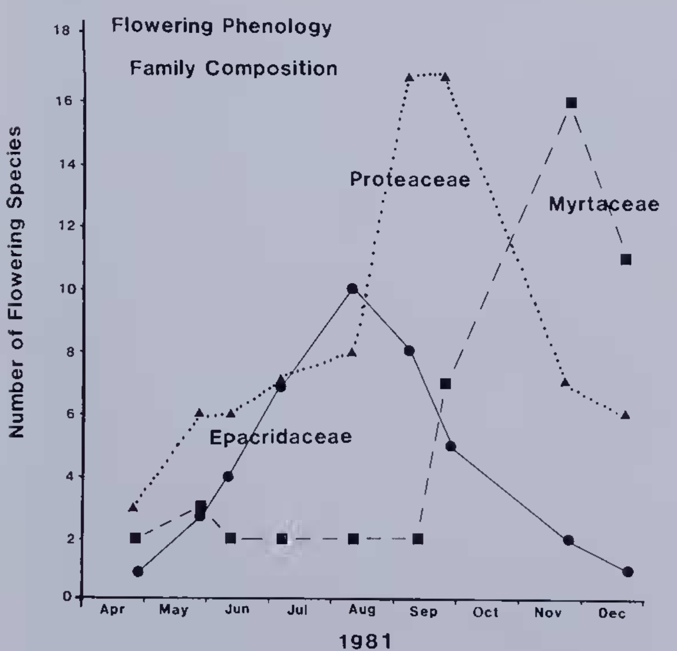

Figure 2.—Total number of Epacridaceae, Myrtaceae and Proteaceae species flowering in 26 heathland study sites in the Northern Sandplain during the period April-December 1981.

The time required for plants to reach reproductive maturity after fire was recorded for 108 species (Appendix 1). Since all species were not present at every site, and sites of one and three years-since-last-fire were not available, the exact number of years to reach reproductive maturity could not be assigned to most species. Many species, therefore, were given values of <2, <4>2, etc. A value of <4>2 means that the species was seen flowering in a four-year-old site, was not seen flowering in a two-year-old site and was not recorded in a three-year-old site, so therefore it flowers within three or four years after a fire. Most of the species (79%) required only two years at the most to begin flowering after fire regeneration.

Several species flowered profusely in the first few years following a fire, but then were only minimally reproductive in older sites. The most conspicuous of these plants was *Verticordia grandis* which produced a mass of bright red flowers in the sites of less that two years old. The fire-stimulated success of species such as *Verticordia grandis, Stirlingia latifolia, Anigozanthos humilis, Pimelea sulphurea,* and others may be a response to light as observed by Stone and Juhren (1951) or induced by substances produced during a fire. Gill and Ingwersen (1976) demonstrated that injection of ethylene, which is produced in large quantities during a fire, into *Xanthorrhoea australis* stimulated the species to flower as it would normally do after a fire. Even though many plants flower only after a fire, there was no difference in the number of species flowering in burnt and unburnt sites (Table 2). The study of several sites over a period of years would probably show some pattern in the number of species flowering after a fire but in this study, the variation between sites of the same age was too great to permit valid comparisons between sites of different ages.

Table 2

Species in flower at each site for 1981 for the 26 Northern Sandplain kwongan study sites.

Site Number	Years Since Last Burn	Date 1981 29.4	28.5	10.6	7.7	5.8	1.9	29.9	20.11	19.12
Sand										
2	>11	0	1	1	5	5	7	—	6	4
14	>11	—	0	1	2	4	5	b	b	b
16	>11	—	1	1	2	4	7	8	11	7
21	>11	1	1	2	2	3	10	8	9	7
7	11	2	0	0	5	8	9	—	4	5
12	11	—	0	1	2	4	9	9	10	7
1	10	0	1	2	3	5	9	—	5	3
17	7	0	1	2	1	3	7	11	12	6
19	6	0	3	4	6	7	7	14	11	8
23	5	2	3	4	5	5	10	10	7	8
3	4	0	3	3	4	7	9	14	10	4
5	2	0	0	0	3	5	9	14	8	4
25	2	2	2	1	5	7	7	11	12	8
9	2	2	2	1	3	4	9	11	4	6
Laterite										
10	>11	—	2	2	b	b	b	b	b	b
13	>11	—	3	3	2	6	6	9	4	4
15	>11	—	3	3	6	8	7	9	6	4
22	>11	2	1	1	5	10	9	20	9	6
8	11	0	1	2	5	9	13	b	b	b
18	7	0	0	1	8	12	7	10	5	1
20	6	0	1	3	3	8	4	10	5	6
24	5	1	1	3	5	9	7	13	8	4
4	4	0	1	2	5	9	6	11	4	4
6	2	0	1	2	4	8	8	11	8	4
26	2	0	0	0	7	10	8	16	9	4
11	2	—	1	—	1	4	5	10	7	5

b = burnt
— = unsampled

There was no evidence that any species ceased flowering once a site reached maturity, i.e. greater than ten years-since-last-fire. The common belief that plants regenerating from seed have a longer juvenile period than sprouting species was unfounded in these results. Species reproducing from seed such as *Dryandra sessilis, D. kippistiana, Petrophile media* and *Leucopogon striatus*, for example, flowered on seedlings which were only two years old. Others, for example, *Hakea obliqua* and *Dryandra carlinioides*, however, required four years before they flowered. In these species a fire interval of three years could be disastrous and may lead to their local extinction. In heath vegetation of South Australia, firing at intervals of less than five years was found likely to eliminate *Banksia ornata*, *Casuarina pusilla* and *Leptospermum myrsinoides*; species which take several years to reach reproductive maturity (Specht *et al.* 1958). In Victorian coastal heaths, *Leptospermum laevigatum* is killed by fire and requires four years before it flowers (Burrell 1968). Short fire intervals would be detrimental to the long term survival of such species.

In the Northern Sandplain region near Badgingarra, the impact of fire on the availability of flowers important to the bee keeping industry must also be considered. Species of the Epacridaceae, Fabaceae, Mimosaceae and Asteraceae are important pollen-producing species in the Northern Sandplain shrublands. During the winter months, *Leucopogon* species dominated the available flowers at nearly every site on both sand and laterite substrates which had a time-since-last-fire of four years or more. Since it only takes two years for seedlings of *Leucopogon striatus* to flower after a fire, it is unlikely that this species will be eliminated from an area by frequent burning. Another important pollen producer, *Acacia pulchella*, requires fire for establishment and flowering. Most plants of the heathland flower within four years after a fire. Although the dominant *Leucopogon* (winter) and Proteaceae (spring) species present in sites greater than four years since last fire did not dominate in recently burnt areas, the overall number of individuals and species in flower and density of flowering appeared as great in a two year old site as in a ten year old site. Whether the bees can utilise the flora of a recently burnt site though, is as yet untested. Given that honeybees can fly up to 11 km from their hive in search of favourable plants (A. Kessell, pers. comm.), it would take a large fire to render an apiary site completely unusable.

Species conservation management

Crown lands in the region must be managed to control the fuel build-up and a concomitant increase in the potential of uncontrollable fires starting within the shrub communitites and spreading into the adjacent pasture and farmlands, thereby endangering human life and property (Bell and Loneragan, 1985). Other considerations, however, include the conservation of examples of this extremely rich flora and the maintenance of sufficient areas containing flowering species of importance to the honeybee.

Conservation of native flora everywhere is of growing concern since the rate of extinction is increasing rapidly as a result of man's activities (Leigh and Boden 1979). It has been estimated that, in tropical rainforests alone, at least one species is disappearing every day (Myers 1979). What this figure might be in the heathlands of Western Australia would be pure conjecture since many species here have yet to be described (Marchant and Keighery 1979).

The southwestern corner of Western Australia is characterized by a high degree of endemism. Marchant (1973) estimates that 68% of a listed 3 600 angiosperms in the South-West Botanical Province are restricted to this province. Marchant and Keighery (1979), in highlighting the lack of knowledge of the Western Australian flora, list over 2 000 species of vascular plants as being either poorly known or possibly rare or restricted to a small geographic area. With further taxonomic revision of local genera, as much as 25-30% of the south-west flora may be classified as rare (Marchant and Keighery 1979). Twenty-two of the 238 species recorded in the study area can be classified as either rare, restricted or poorly known (Appendix 1). One species (*Eucalyptus pendens*) is classified as being rare and occurring in a restricted habitat. Only two small populations were observed in the lateritic sandplains of the southeastern section of the Badgingarra National Park. Seven species (*Cassytha pubescens*, *Dampiera lindleyi*, *Gastrolobium bidens*, *Hibbertia glaberrima*, *H. pilosa*, *Leucopogon crassifolia* and *Xanthorrhoea reflexa*) rank as poorly known, with only 2-5 specimens preserved in the Western Australian Herbarium. Six species (*Blancoa canescens*, *Conospermum nervosum*, *Daviesia epiphylla*, *Dryandra nana*, *D. tridentata* and *Hakea flabellifolia)* are classified as restricted to areas of less than 100 km diameter. Of these rare or poorly known species, six regenerate from seed and are therefore considered in most danger of elimination by fire, and, since a two year old site is probably incapable of carrying a fire, they are unlikely to be eliminated by this means alone. More data are needed on the flowering characteristics of *Gastrolobium bidens*, *Leucopogon crassifolius* and *Conospermum nervosum* to determine how many years are required after a fire before these species flower.

The remaining species collected from the study area which are not rare, restricted or poorly collected, all flower within five years after a fire. Most species were found to regenerate after fire by sprouting and are therefore not in danger of elimination from fire. Although the seed-regenerating species *Hakea obliqua* and *Dryandra carliniodes* require at least four years to flower following fire, neither are rare, nor restricted so are unlikely to be in danger of extinction from frequent fires.

Bee pasture management

The winter "hive-buildup" period in the Northern Sandplain heathlands is of major importance to the apicultural industry. During the early winter months, pollen collection from species of *Leucopogon* predominates. At least four years are required after a fire before *Leucopogon striatus*, the most abundant of the winter flowering *Leucopogon* spp., returns to flowering in abundance comparable to unburnt sites. During the first four years following fire, there are as many species flowering as in an unburnt site but since *L. striatus* is not flowering abundantly it is unknown whether recently burnt sites are capable of supporting an apiary site. Comparisons of the expected distances foraged by honeybees and the observations of fire scars visible in Landsat photographs of the northern sandplain indicate that fires of such magnitude to render an apiary site unusable have never been attained in years prior to 1984. Observations of flowering of old sites and especially important honeybee pollen species such as *Leucopogon striatus* indicates that no decline in flowering intensity appears with increasing site age. Therefore, there would appear to be no disadvantage to the apiarist in leaving a site unburned for many years and their claims for long-term fire protection may be based more on subjective visual assessment of apparent flowering intensity.

Fire hazard reduction

In monetary terms, fire is probably the cheapest management tool used in manipulating vegetation today. The introduction of prescribed burning in reducing the hazard of uncontrollable high-intensity fires has been widely used in forests, wilderness areas, nature reserves and national parks in the last decade or so in Australia (Gill 1977). The development of large areas of the northern Sandplain heathlands for crop and agricultural uses since the 1960's places these at some risk from wildfires. The disastrous Beekeepers Reserve fire of January 1984 burned over 117 000 ha (Burking and Kessell 1984) and Northern Sandplain shrubland fires between February and May 1985 destroyed another 63 400 ha (Davies 1985). The losses in economic terms to the beekeeping industry could reach more than 5 million dollars over the next eight years (Davies 1985). The impact on conservation, tourism and the cut-flower and native seed industries is difficult to estimate but could also be considerable. For these reasons, alone, a policy on fire management for the Northern Sandplain shrublands is essential.

Before the establishment of farms and roads in the Badgingarra area, fires were a common occurrence on crown land during the late summer and autumn months. These fires appear to have been lit by lightning and usually burnt, uncontrolled, for one or two days before going out naturally (A. E. Eastwood, pers. comm.). Lightning is such a common occurrence during summer thunderstorms over this lateritic country that as soon as an area is capable of carrying a fire the chances of it remaining unburnt for any great length of time would seem to be low. The vegetation of sand and lateritic communities recovers to maximum cover in an average of eight years (Bell *et al.* 1984). More material capable of combustion, however, is available as the age of a kwongan stand increases up to at least 20 years. Therefore, the longer a "burnable" site is left unburnt, the more intense would be a fire and its potential destructive force.

The policy of "let nature take its own course" has operated advantageously in most large national parks in the past and is still in practice in many at present (Gill 1977). However, in areas of multiple land use, controlled fires under chosen conditions are more desirable to uncontrolled fires which may prove difficult to confine. Controlled burning of the Northern Sandplain area would necessarily involve rotational burning to eventually produce a mosaic of differing ages since-last-fire. Areas of more than 11 years-since-last-fire are however, becoming increasingly scarce. Efforts should therefore be made to create some areas which are protected from fire for as long as possible to allow for further research. These areas should not border on farmland in case of a wildfire. Ideally they should be enclosed by a wide buffer strip which is burnt more frequently and a fire break so that the chances of the area being burnt are reduced.

Any manipulation of the environment by man should attempt to closely reproduce the events of nature as much as possible. Applying this to fire management policies, it would be desirable to have controlled fires at a frequency close to that under more natural conditions. Policies of very frequent burning, or complete fire suppression should be avoided. Results from this study suggest the natural fire frequency in the Badgingarra area could be as low as between 8 and 15 years. A policy of controlled burning every 10 years in a mosaic pattern would: (1) be unlikely to cause any loss of species; (2) be unlikely to badly interfere with the apicultural industry unless the area burnt was very large; (3) would reduce the risk of uncontrolled wildfires; and (4) would closely simulate the actual fire pattern of the area under natural conditions.

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References

Baird, A. M. (1977).—Regeneration after fire in King's Park, Perth, Western Australia. *J. Roy Soc. West. Aust.*, **60**: 1-22.

Beadle, N. C. W. (1940).—Soil temperatures during forest fires and their effect on the survival of vegetation. *J. Ecol.*, **28**: 180-92.

Bell, D. T. (1985).—Aspects of response to fire in the Northern Sandplain Heathlands. In *Fire Ecology and Management in Western Australian Ecosystems*, J. R. Ford, (ed.). pp. 33-40. WAIT Environmental Studies Group Report No. 14, Bentley, Western Australia.

Bell, D. T., Hopkins, A. J. M. and Pate, J. S. (1984).—Fire in the Kwongan. *In Kwongan-Plant Life of the Sandplain*, Pate J. S. and Beard, J. S. (eds.) pp. 178-204. University of Western Australian Press, Nedlands, Western Australia.

Bell, D. T. and Koch, J. M. (1980).—Post-fire succession in the northern jarrah forest of Western Australia. *Aust. J. Ecol.*, **5**: 9-14.

Bell, D. T. and Loneragan, W. A. (1985)—The relationship of fire and soil type to floristic patterns within heathland vegetation near Badgingarra, Western Australia. *J. Roy. Soc. West. Aust.*, **67**: 98-109.

Biswell, H. H. (1974). Effects of fire on chaparral. In *Fire and Ecosystems*. Kozlowski, T. T. and Ahlgren, C. E. (eds) pp. 321-364. Academic Press, N. Y.

Burking, R. C. and Kessell, A. C. (1984).—Damage report of the west-coastal wildfire and its effects on the Western Australian Beekeeping Industry. Western Australian Department of Agriculture Report.

Burrell, J. (1986).—The invasion of Victoria heathlands by *Leptospermum laevigatum*. *Proc. Ecol. Soc. Aust.*, **3**: 39.

Christensen, N. L. and Muller, C. H. (1975).—Effects of fire on factors controlling plant growth in *Adenostoma* chaparral. *Ecol. Monogr.*, **45**: 29-55.

Christensen, P. E. and Kimber, P. C. (1975).—Effects of prescribed burning on the flora and fauna of south-west Australian Forests. *Proc. Ecol. Soc. Aust.*, 9: 85-106.

Churchill, D. M. (1968).—The distribution and prehistory of *Eucalyptus diversicolor* F. Muell., *E. marginata* Donn ex Sm. and *E. calophylla* R. Br. in relation to rainfall. *Aust. J. Bot.*, **16**: 125-151.

Cushwa, C. T., Martin, R. E. and Miller, R. L. (1968).—The effects of fire on seed germination. *J. Range Manage.*, **21**: 250-254.

Davies, J. (1985).—The impact of fire on the apiary industry. In *Fire Ecology and Management in Western Australia Ecosystems*, J. R. Ford, (ed.) pp. 209-213. WAIT Environmental Studies Group Report No. 14, Bentley, Western Australia.

Ewart, A. J. (1908).—On the longevity of seeds. *Proc. Roy. Soc. Vict.*, **21**: 1-210.

Floyd, A. G. (1966).—Effect of fire upon weed seeds in the wet sclerophyll forests of northern New South Wales. *Aust. J. Bot.*, **14**: 213-256.

Floyd, A. G. (1976).—Effect of burning on regeneration from seeds in wet sclerophyll forest. *Aust. For.*, **39**: 210-220.

Gill, A. M. (1975).—Fire and the Australian flora: A review. *Aust. For.*, **38**: 4-25.

Gill, A. M. (1977).—Management of fire-prone vegetation for plant species conservation in Australia. *Search*, **8**: 20-26.

Gill, A. M. and Ingwersen, I. (1976).—Growth of *Xanthorrhoea australis* R. Br. in relation to fire. *J. Appl. Ecol.*, **13**: 195-203.

Hnatiuk, R. J. and Hopkins, A. J. M. (1980).—Western Australian species-rich Kwongan (sclerophyllous shrubland) affected by drought. *Aust. J. Bot.*, **28**: 573-585.

Hopkins, A. J. M. (1979).—Ecological aspects of the lignotuber. Abstract of paper presented at the Symposium on the Biology of Native Australian Plants. Perth, W. A. 6-10 August, 1979.

Keeley, J. E. and Zedler, P. H. (1978).—Reproduction of chaparral shrubs after fire: A comparison of sprouting and seeding strategies. *Amer. Midl. Nat.*, **99**: 142-161.

Lamont, B. B., Hopkins, A. J. M. and Hnatiuk, R. J. (1984).—The flora-composition, diversity and origins. In *Kwongan-Plant Life of the Sandplains*, Pate, J. S. and Beard, J. S.(eds.) pp. 27-50. University of Western Australia Press, Nedlands, Western Australia.

Leigh, J. and Boden, R. (1979).—Australian flora in the endangered species convention-CITES. Australian National Parks and Wildlife Service Special Publication No. 3, pp. 93.

McArthur, A. G. and Cheney, N. P. (1966).—The characterization of fires in relation to ecological studies. *Aust. For. Res.*, **2**: 36-45.

Marchant, N. G. (1973).—Species diversity in the south-western flora. *J. Roy. Soc. West. Aust.*, **56**: 23-30.

Marchant, N. G. and Keighery, G. J. (1979).—Poorly collected and presumably rare vascular plants of Western Australia. *Kings Park Res. Notes* No. 5.

Morrow, P. A. (1977).—Host specificity of insects in a community of three co-dominant *Eucalyptus* species. *Aust. J. Ecol.*, **2**: 89-106.

Myers, N. (1979).—*The Sinking Ark*. Pergamon, Oxford, England.

Russell, R. P. and Parsons, R. F. (1978).—Effects of time since fire on heath floristics at Wilson's Promontory, Southern Australia. *Aust. J. Ecol.*, **26**: 53-61.

Rye, B. L. (1982).—Geographically restricted plants of southern Western Australia. *Dept. Fish Wildl. West. Aust. Rept.* No. 49.

Shea, S. R., McCormick, J. and Portlock, C. C. (1979).—The effect of fires on the regeneration of leguminous species in the northern jarrah (*Eucalyptus marginata* Sm.) forest of Western Australia. *Aust. J. Ecol.*, **4**: 195-205.

Siddiqi, M. Y., Carolin, R. C. and Myerscough, P. J. (1976).—Studies in the ecology of coastal heath in New South Wales. III. Regrowth of vegetation after fire. *Proc. Linn. Soc. N. S. W.*, **101**: 53-63.

Specht, R. L. (1979).—Heathlands and related shrublands of the world. In *Ecosystems of the World. Vol. 9A. Heathlands and Related Shrublands* R. L. Specht, (Ed.) pp. 1-18, Chapter 1. Elsevier: Amsterdam.

Smith, F. G. (1969).—Honey Plants of Western Australia. *West. Aust. Dept. Agric. Bull.*, **3618**.

Specht, R. L, Rayson, P. and Jackman, M. E. (1958).—Dark Island heath (Ninety-Mile Plain, South Australia), VI. Pyric Succession: changes in composition, coverage, dry weight, and mineral nutrient status. *Aust. J. Bot.*, **6**: 59-88.

Stone, E. C. and Juhren, G. (1951).—The effect of fire on the germination of the seed of *Rhus ovata* Wats. *Amer. J. Bot.*, **38**: 368-372.

Went, F. W., Juhren, G. and Juhren, M. C. (1952).—Fire and biotic factors affecting germination. *Ecology*, **33**: 351-364.

Appendix 1.

Vascular plant species of the northern sandplain honey bee pasture region. Annotated information where known includes edaphic preference, most preferred fire response mode, the juvenile period between fire and flower production and the dates of 1981 where flowering was recorded. Annotation codes. [1]Flowering mainly restricted to period 1 or 2 years following fire; [2]Flowering restricted to period 2-4 years after fire; [3]Flowers earlier in season in 2-4 year old sites; [4]Species that are apparently rare and have a restricted geographic distribution (after Marchant and Keighery 1979); [5]Species poorly known (after Marchant and Keighery 1979); [6]Distribution restricted to an area with 100 km diameter (after Marchant and Keighery 1979); [7]Distribution restricted to an area with 160 km diameter (after Marchant and Keighery 1979).

Species	Edaphic Preference	Fire Response	Juvenile Period	Flowering Period								
				4 29	5 28	6 10	7 7	8 5	9 1	9 29	11 20	12 19
GYMNOSPERMAE												
Cupressaceae												
Actinostrobus acuminatus Parlat	Generalist	Sprout									x	x
ANGIOSPERMAE-MONOCOTYLEDONAE												
Cyperaceae												
Caustis dioeca R. Br.	Generalist	Sprout										
Mesomelaena stygia (R. Br.) Nees	Generalist	Sprout										
Mesomelaena tetragona (R. Br.) Benth	Generalist	Sprout										
Schoenus curvifolius (R. Br.) Benth	Generalist	Sprout										
Haemodoraceae												
Anigozanthos humilis Lindl.	Sand	Sprout	≤2						x	x		
Blancoa canescens (Lindl.) Baill.	Sand	Sprout	<2[2]	x	x	x	x	x				
Conostylis androstemma Lindl.	Laterite	Sprout						x				
Conostylis aurea Lindl.	Generalist	Sprout	≤2							x	x	
Conostylis filifolia F. Muell		Sprout	≤2					x	x			
Conostylis teretifolia J. W. Green	Generalist	Sprout										
Haemodorum paniculatum Lindl.		Sprout										
Macropidia fuliginosa Drum	Laterite	Sprout										
Phlebocarya ciliata R. Br.		Sprout										
Iridaceae												
Patersonia occidentalis R. Br.	Generalist	Sprout	≤2								x	
Liliaceae												
Burchardia umbellata R. Br.	Generalist	Sprout	≤2							x		
Johnsonia pubescens Lindl.	Sand	Seed	≤2					x	x	x		
Laxmannia grandiflora Lindl.	Generalist	Seed						x	x			
Laxmannia sp. aff. *sessiliflora*		Seed										
Thysanotus glaucus Endl.	Sand	Seed									x	x
Thysanotus multiflorus R. Br.	Sand	Seed	≤2								x	x
Orchidaceae												
Diuris longifolia R. Br.	Laterite	Sprout	1				x					
Glossodia brunonsis (Endl.) A. S. George	Laterite	Sprout								x		
Prasophyllum parviflorum Lindl.	Laterite	Sprout	≤2				x	x				
Pterostylis nana R. Br.		Sprout										
Thelymitra sp. aff. variegata Lindl	Laterite	Sprout										
Poaceae												
Neurachne alopecuroides R. Br.		Sprout										
Restionaceae												
Alexgeorgia arenicola Carlquist	Generalist	Sprout										
Anarthria laevis R. Br.	Generalist	Sprout										
Ecdeiocolea monostachya F. Muell	Generalist	Sprout										
Hypolaena exsulca R. Br.	Sand	Sprout										
Lyginea barbata R. Br.	Generalist	Sprout										
Xanthorrhoeaceae												
Calectasia cyanea R. Br.	Generalist	Sprout	<2				x	x	x	x	x	x
Dasypogon bromeliifolius R. Br.	Sand	Sprout	<2[1]						x	x		
Kingia australis R. Br.	Laterite	Sprout	<2[1]									
Xanthorrhoea reflexa Herbert.[7]	Laterite	Sprout	<2[1]									
ANGIOSPERMAE-DICOTYLEDONAE												
Apiaceae												
Xanthosia huegelii (Benth.) Steud	Sand											

Appendix 1—*continued*

Species	Edaphic Preference	Fire Response	Juvenile Period	Flowering Period								
				4 29	5 28	6 10	7 7	8 5	9 1	9 29	11 20	12 19
Asteraceae												
Angianthus tomentosus Wendle.	Generalist	Seed	<2									
Arctotheca calendula (L.) Leogns.		Seed	1									
Helipterum cotula (Benth.) D. C.	Sand	Seed	1									
Podotheca gnaphalioides (Grah.) F. Muell.		Sprout										
Podotheca pygmaea A. Gray		Seed	1									
Ursinia anthemoides (L.) Poir.		Seed	1									
Caesalpiniaceae												
Labichea punctata Benth.	Laterite	Sprout	<2							x		
Casuarinaceae												
Allocasuarina humilis Otto & Dietr.	Generalist	Sprout			x	x	x					
Allocasuarino microstachya Miq.	Laterite	Sprout										
Chloanthaceae												
Lachnostachys verbascifolia F. Muell.	Sand	Sprout										
Pityrodia bartlingii (Lehm.) Benth.	Sand	Sprout	<2								x	
Dilleniaceae												
Hibbertia acerosa (R. Br.) Benth.	Sand	Sprout									x	x
Hibbertia aurea Steud.	Laterite	Sprout								x		
Hibbertia crassifolia (Turcz.) Benth.	Generalist	Sprout	<2					x	x	x		
Hibbertia glaberrima F. Muell.	Sand	Seed & Sprout	<2							x	x	x
Hibbertia huegelii (Endl.) F. Muell.	Generalist	Sprout	<2						x	x	x	
Hibbertia hypericoides (DC.) Benth.	Generalist	Sprout	<2					x	x	x	x	
Hibbertia pilosa Steud.	Laterite	Sprout						x	x	x		
Hibbertia racemosa (Endl.) Gilg.	Sand	Sprout										
Droseraceae												
Drosera drummondii Lehm.	Laterite	Seed							x			
Drosera erythrorrhiza Lindl.		Sprout										
Drosera heterophylla Lindl.	Generalist	Sprout	<2					x	x			
Drosera macrantha Endl.	Sand	Sprout	<2							x		
Drosera menziesii R. Br.		Sprout										
Drosera paleacea DC.		Seed										
Drosera pallida Lindl.												
Epacridaceae												
Andersonia heterophylla Sond.	Sand	Seed & Sprout	≤4				x	x	x			
Andersonia lehmanniana Sond.	Generalist	Sprout	≤4			x	x	x				
Astroloma microdonta (F. Muell.) Benth.	Laterite	Seed	≤4		x	x	x	x	x	x		
Astroloma pallidum R. Br.	Laterite	Sprout	≤2		x	x	x					
Astroloma serratifolium (DC.) Druce	Generalist	Sprout	≤2					x				
Astroloma stomarrhena Sond.	Generalist	Sprout	≤2				x	x	x			
Astroloma xerophyllum (DC.) Sond.	Sand	Seed	≤4					x	x			
Conostephium pendulum Benth.	Sand	Sprout	≤5					x				
Leucopogon striatus	Generalist	Sprout & Seed	≤2	x	x	x	x	x	x	x		
Leucopogon conostephioides DC.	Generalist	Seed	≤5				x	x				
Leucopogon crassiflorus F. Muell.[5]	Sand		≤5					x	x	x		
Leucopogon cryptanthus Benth.	Generalist										x	x
Lysinema ciliatum R. Br.	Sand	Seed	≤4					x	x	x		
Euphorbiaceae												
Monotaxis grandiflora Endl.												
Goodeniaceae												
Dampiera juncea Benth.	Generalist									x	x	x
Dampiera lindleyi De Vriesse[5]	Laterite	Sprout										
Dampiera spicigera Benth.	Sand	Sprout								x	x	
Dampiera stenostachya E. Pritzel.												
Lechenaultia biloba Lindl.	Laterite	Sprout	≤2							x		
Lechenaultia floribunda Benth.		Seed										
Lechenaultia formosa R. Br.	Sand										x	x
Scaevola canescens Benth.	Sand	Sprout						x	x			
Scaevola glandulifera DC.											x	x
Scaevola paludosa R. Br.	Sand	Sprout										
Velleia trinervis Labill.	Sand	Seed									x	x
Verreauxia villosa E. Pritzel	Sand	Seed	2								x	x
Haloragaceae												
Glisschrocaryon aureum var. *aureum* (Lindl.) Orch.										x		
Lauraceae												
Cassytha pubescens R. Br.[5]	Sand	Seed										
Lamiaceae												
Hemiandra pungens R. Br.	Sand	Sprout									x	x
Lobeliaceae												
Lobelia gibbosa Labill.												

Appendix 1—*continued*

Species	Edaphic Preference	Fire Response	Juvenile Period	Flowering Period 4 29	5 28	6 10	7 7	8 5	9 1	9 29	11 20	12 19
Loganiacea												
Logania spermacocea F. Muell.	Generalist										x	x
Loranthaceae												
Nuytsia floribunda (Labill.) R. Br.	Sand	Sprout										
Malvaceae												
Plagianthus monoica Ewart												
Mimosaceae												
Acacia auronitens Lindl.		Sprout & Seed										
Acacia cedroides Benth.	Laterite		≤2				x	x				
Acacia lasiocarpa Benth.	Laterite	Seed										
Acacia pulchella R. Br.	Generalist	Seed	≤5>2					x	x			
Acacia spinosissima Benth.	Sand											
Acacia stenoptera Benth.		Sprout	≤5>2		x	x	x					
Acacia teretifolia Benth.	Laterite							x				
Myrtaceae												
Baeckea camphorosmae Endl.	Generalist									x		
Baeckea crispiflora F. Muell.	Latertite											
Baeckea grandiflora F. Muell.	Laterite	Sprout	<4>2							x	x	x
Beaufortia bracteosa Deils.		Seed										
Beaufortia elegans Schau.	Sand	Seed	≤2								x	x
Beaufortia eriocephala W. V. Fitzg.	Laterite	Sprout & Seed	<2								x	x
Beaufortia squarrosa Schau.		Seed	<2								x	x
Calothamnus sanguineus Labill.	Generalist	Sprout	<4	x	x	x	x	x	x	x	x	x
Calothamnus torulosus Schau.	Laterite	Sprout	≤5>2							x		
Calytrix brachyphylla Turcz.	Sand	Sprout	<2									
Calytrix flavescens A. Cunn.	Sand										x	x
Calytrix muricata F. Muell.	Sand											
Conothamnus trinervis Lindl.	Generalist	Sprout	≤2							x		
Darwinia speciosa (Meissn.) Benth.	Generalist	Sprout										
Eremaea beaufortioides Benth.	Generalist	Sprout	≤2[2]							x	x	x
Eremaea fimbriata Lindl.	Generalist	Seed										
Eucalyptus macrocarpa Hook.	Sand	Sprout										
Eucalyptus pendens Brooker[7]	Laterite	Sprout										
Eucalyptus todtiana F. Muell.	Sand	Sprout										
Hypocalymma xanthopetalum F. Muell.	Generalist	Sprout	≤2				x	x	x			
Leptospermum spinescens Endl.	Generalist	Sprout									x	
Melaleuca depressa Diels.	Generalist	Sprout									x	x
Melaleuca scabra R. Br.	Generalist	Sprout								x	x	x
Melaleuca trichophylla Lindl.	Laterite	Sprout	<4>2							x	x	
Pileanthus filifolius Meissn.	Generalist		<4								x	x
Verticordia densiflora Lindl.	Generalist	-									x	
Verticordia grandiflora Endl.	Generalist	Seed	<4							x		
Verticordia grandis Drumm.[7]	Sand	Sprout	<2	x	x	x					x	x
Verticordia spicata F. Muell.												
Verticordia ovalifolia Meissn.											x	x
Papilionaceae												
Daviesia aphylla (F. Muell.) Benth.	Laterite	Sprout	≤2							x		
Daviesia daphnoides Meissn.	Laterite	Sprout		x	x	x	x					
Daviesia divaricata Benth.	Sand	Sprout	≤2					x				
Daviesia epiphylla Meissn.[6]	Laterite	Sprout										
Daviesia juncea Sm.	Laterite	Sprout								x		
Daviesia nudiflora Meissn.	Generalist	Sprout	≤2				x	x				
Daviesia pectinata Lindl.	Generalist	Sprout	≤2				x	x				
Daviesia pedunculata Benth.	Generalist	Sprout	<2							x		
Daviesia preissii Meissn.	Generalist	Sprout		x	x							
Daviesia quadrilatera Benth.	Sand	Seed	≤2				x	x	x			
Daviesia striata Turcz.	Laterite	Sprout		x								
Gastrolobium bidens Meissn.[5]	Laterite	Seed						x	x			
Gastrolobium ilicifolium Meissn.	Laterite											
Gastrolobium obovatum Benth.	Laterite	Sprout	≤5					x				
Gastrolobium oxylobioides Benth.	Laterite	Sprout										
Gastrolobium spinosum Benth.	Laterite	Seed									x	x
Gastrolobium knightianum Lindl.	Laterite	Sprout										
Hovea stricta Meissn.[7]	Generalist	Sprout	≤2		3	x	x	x				
Isotropis cuneifolia (Sm.) Domin.	Generalist	Sprout	≤2[2]								x	x
Jacksonia floribunda Meissn.	Sand	Seed & Sprout	≤2							x	x	
Jacksonia restioides Hueg.	Generalist											
Jacksonia sternbergiana R. Br.	Laterite	Seed										
Kennedia prostrata R. Br.	Laterite	Seed										
Oxylobium capitatum Benth.	Laterite											
Sphaerolobium macranthum Meissn.	Laterite									x		
Phytolaccaceae												
Gyrostemon ramulosus Desf.	Sand	Seed	<2									x
Tersonia brevipes Moq.	Sand	Seed	<2						x	x	x	x
Pittosporaceae												
Billardiera bicolor (Putterl.) E. M. Bennett	Laterite											

Appendix 1—*continued*

Species	Edaphic Preference	Fire Response	Juvenile Period	Flowering Period 4 29	5 28	6 10	7 7	8 5	9 1	9 29	11 20	12 19
Polygalaceae												
Comesperma calymega Labill.	Generalist	Sprout	≤2							x	x	x
Proteaceae												
Adenanthos eygnorum Dies	Sand	Seed									x	
Banksia attenuata Meissn.	Sand	Sprout & Seed	<2								x	x
Banksia candolleana Meissn.[7]	Sand	Sprout	≤4>2	x	x	x	x	x				
Banksia menziesii R. Br.	Laterite	Sprout	≤2	x	x	x	x	x	x			
Banksia prostrata R. Br.	Laterite	Sprout	≤2								x	
Banksia sphaerocarpa R. Br.	Generalist	Seed & Sprout										x
Banksia sp. aff. *sphaerocarpa* R. Br.	Generalist	Seed & Sprout	≤2		x	x	x					x
Conospermum acerosum Lindl.	Sand	Sprout								x		
Conospermum incurvum Lindl.	Sand	Sprout	<5								x	
Conospermum nervosum Meissn.[6]	Laterite	Seed										
Conospermum stoechadis Endl.	Sand	Sprout	<2							x		
Conospermum triplinervium R. Br.	Sand	Sprout	<2	x	x	x					x	x
Dryandra bipinnatifida R. Br.	Laterite	Sprout & Seed										
Dryandra carlinoides Meissn.	Generalist	Seed	≤4>2							x		
Dryandra kippistiana Meissn.	Laterite	Seed	<2						x	x		
Dryandra nana Meissn.[5]	Generalist	Sprout	<2							x		
Dryandra nivea R. Br.	Generalist	Sprout								x		
Dryandra sessilis (R. Br.) Druce	Laterite	Seed	≤2							x		
Dryandra shuttleworthiana Meissn.	Generalist	Sprout										
Dryandra tridentata Meissn.[6]	Sand	Sprout	<2							x		
Grevillea pilulifera (Lindl.) C. A. Gardn.	Generalist	Sprout					x	x	x			
Grevillea shuttleworthiana Meissn.	Sand	Sprout							x			
Grevillea synapheae R. Br.	Laterite	Seed	≤2					x	x	x		
Hakea auriculata Meissn.	Laterite	Sprout	≤2					x	x	x		
Hakea conchifolia Hook.	Laterite	Sprout	<2			x	x	x	x			
Hakea corymbosa R. Br.	Generalist	Sprout							x			
Hakea costata Meissn.	Sand	Seed	≤6						x			
Hakea flabellifolia Meissn.[6]	Generalist	Sprout										
Hakea incrassata R. Br.	Laterite	Sprout	≤2					x				
Hakea lissocarpha R. Br.	Generalist	Sprout			x	x	x	x				
Hakea obliqua R. Br.	Sand	Seed	≤4							x		
Hakea prostrata R. Br.	Sand	Sprout							x			
Hakea ruscifolia Labill.	Sand											
Hakea sulcata var. *scoparia* R. Br	Laterite	Seed							x			
Hakea undulata R. Br.												
Isopogon asper R. Br.	Laterite		<2						x			
Isopogon linearis Meissn.[7]		Sprout	≤4>2						x			
Isopogon teretifolius R. Br.												
Lambertia multiflora Lindl.	Generalist	Sprout	≤2						x	x	x	
Persoonia dillwynioides Meissn.	Laterite	Sprout	≤4								x	x
Petrophile inconspicua Meissn.	Generalist	Sprout & Seed						x				
Petrophile linearis R. Br.	Sand	Sprout	≤2							x		
Petrophile macrostachya R. Br.	Generalist	Sprout	≤4							x		
Petrophile media R. Br.	Generalist	Seed	≤2						x	x		
Petrophile serruriae R. Br.												
Petrophile striata R. Br.	Generalist	Sprout & Seed								x		
Stirlingia latifolia (R. Br.) Steud.	Sand	Sprout	≤2						x			
Stirlingia simplex Lindl.		Sprout										
Strangea cyanchicarpa F. Muell.[7]	Sand	Sprout										
Synaphaea petiolaris R. Br.	Laterite	Sprout							x	x		
Synaphaea polymorpha R. Br.	Generalist	Sprout & Seed	≤2						x	x		
Rhamnaceae												
Cryptandra arbutiflora Fenzl.												
Cryptandra pungens Steud.												
Spyridium tridentatum (Steud.) Benth.	Laterite				x	x	x	x				
Spyridium sp. aff. tridentatum (Steud.) Benth.	Generalist	Seed	≤2					x	x	x		
Trymalium ledifolium Fenzl.	Laterite											
Rutaceae												
Boronia ramosa (Lindl.) Benth.	Laterite											
Eriostemon spicatus A. Rich	Generalist	Sprout	≤2							x		
Stackhousiaceae												
Stackhousia brunonsis Benth.	Laterite	Sprout & Seed	≤2							x		
Stackhousia pubescens A. Rich	Sand											
Sterculiaceae												
Commersonia pulchella Turcz.	Sand											
Lasiopetalum drummondii Benth.[7]	Generalist	Sprout	≤2									
Lasiopetalum sp.												
Thomasia grandiflora Lindl.	Laterite	Sprout	≤2					x	x	x		

Appendix 1—*continued*

Species	Edaphic Preference	Fire Response	Juvenile Period	Flowering Period 4 29	5 28	6 10	7 7	8 5	9 1	9 29	11 20	12 19
Stylideaceae												
Stylidium adpressum Benth.		Seed										
Stylidium leptophyllum DC.		Seed										
Stylidium piliferum ssp. *minor* (Mildbr.) Carlq.	Laterite	Seed	≤2[2]							x		
Stylidium repens R. Br.	Generalist	Seed	≤2			x	x	x				
Thymeleaceae												
Pimelea angustifolia R. Br.	Generalist	Sprout										
Pimelea floribunda Meissn.		Seed										
Pimelea imbricata R. Br.												
Pimelea suaveolens (Endl.) Meissn.	Laterite	Seed	≤2[2]									
Pimelea sulphurea Meissn.		Sprout & Seed								x		
Tremandraceae												
Tetratheca confertifolia Steetz.	Laterite									x	x	x
Violaceae												
Hybanthus calycinus (Steud.) F. Muell												
Hybanthus floribundus (Walp.) F. Muell	Laterite		≤2				x	x				